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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Observing atmospheric formaldehyde (HCHO) from space: validation and intercomparison of six retrievals from four satellites (OMI, GOME2A, GOME2B, OMPS) with SEAC^{4}RS aircraft observations over the Southeast US" *by* L. Zhu et al.

Anonymous Referee #2

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General Comments This paper presents intercomparison results for HCHO vertical columns measurements from 4 satellite instruments and 6 different retrievals and comparison to an aircraft campaign over the Southeast US. The paper is easy to read and very interesting for the community in order to have a better view of the quality of the existing satellites HCHO retrievals. It is within the scope of ACP and should be published after taking into account the comments and improvements listed below.

Specific Comments page 3, line 3: it's the only point in the paper where the in-situ

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data (reference and technique) are introduced, and as the whole paper is based on these measurements, it would be good to say a little more about them (maybe at the beginning of Section 3). What is their accuracy, sensitivity, ... see comment relative to page 4.

page 3, line 10: to my view, Table 1 should contain more information on the different retrievals. It should highlight the main differences between the various retrievals made on the same satellite sensor. Other differences than only the CTM are important: the albedo, surface, cloud correction, etcc (that are only mentioned in page 8) that impact AMF calculation, but also differences in DOAS settings for the slant column retrieval.

page 4, line 16: and applied Equation (1) "to" compute ... page 4, line 17: AMF based on the its reported: remove "the" or "its".

page 4, section 3: I would add a small paragraph on the 2 insitu techniques that are mentioned in the introduction, and that are considered the "truth" but that have 10% difference, as stated in line 31. Any hint on why? The organization of the figure sequence in this section is a little bit confusing for me (the different part of each figures are not discussed/mentioned together, but at different moments of section 3): first figure 1 (but only right and upper left panels), then Figure 2 (left panel), then bottom left panel of figure 1 (p.5, line 18), then figure 3 (p.5, line 20), then missing reference to figure 4 (p.5, line 29) and then only in page 6, the right panel of figure 2 is presented/mentioned. Maybe the bottom left panel of figure 1 could go with figure 3 and the right panel of figure 2 could go after figure 4?

page 4, line 24: it is stated that the typical extension of the mixed layer is to 1.5-2 Km in the afternoon, but in figure 1, the caption mention 1 to 3km. It would be good to add the height scale in km on the profile picture (and not only pressure) in order to easily make the link with the figure.

page 4, line 26: most flight hours were in the afternoon. How much is "most"? page 4, line 27: the diurnal variability is expected to be small. How much is "small"?

page 5, line 5: considering the 10% difference between the 2 in-situ technique, why is CAMS considered as the reference in the rest of the paper (GEOS-CHEM is increased by 10% to reach CAMS values) and not ISAF or the average of both?

page 5, line 29: add "as can be seen in figure 4, " before "Initial simulations ..." page 5, line 31: add "previous"before "comparisons of GEOS-FP ..."

page 6, line 1: add "red line in" before "figure 4". page 6, line 11: how do you "remove this dependence on altitude"? again, it would be helpful for an easy reading of the paper, to mention the limits of the mixed layer and of the free troposphere in pressure values. page 6, line 18: why only mention the spatial correlation with CAMS data and not with ISAF? page 6, line 26 and lower and Table 2: the spatial (and temporal) correlation coefficient calculation should be mentioned in the text here, and not only in the caption of Table 2.

page 6, line 29: GOME-2A BIRA is noisier wrt GOME-2B, this is clear. How much is this due do degradation and how much to the reduced swath mode?

page 7, line 2: "GEOS-Chem columns are sampled on the same schedule and scenes as the individual retrievals" but as GOME2A and GOME2B does not have the same swath, the pixels geometry and cloud impact are not the same, so why the value of GEOS-Chem columns in table 3 is the same (1.59) for both instruments?

page 7, line 8 to 14: This would be a good place to discuss the different retrieval choices and their impacts on the different retrieval steps (corrected slant column, AMF and background correction).

page 7, line 22: after discussing the OMI-BIRA shape factors (ie the IMAGES input) wrt to CAMS profile, you could discuss the other model shapes too? and how are GEOS-CHEM and IFAS profile? is this difference between model expected/known? what is the possible difference explanation?

page 7, line 29: the "much smaller" affirmation in the sentence "The differences with

the original AMFs are less than 6.0%, a much smaller correction than for OMI-BIRA" would be more clear with "are less than 0.06, while for OMI-BIRA the change in AMF is around the double (-0.14)".

page 8, line 2: not only "driven by scattering weights and viewing angles". The clouds, albedo, aerosols also impacts the AMFs. page 8, line 5: the difference in surface reflectivity between OMI-SAO and OMI-BIRA is not so small ($\sim$23 to 29%). this certinaly impact (and not only "would contribute in part) "the difference in scattering weights ar lower altitudes". Please refer to sensitivity tests and AMF error estimations from literature.

page 8, line 8: the sentence "The scattering weights of OMI-BIRA are lower than those of GOME2B-BIRA (Figure 6) and GOME2A-BIRA (about the same as GOME2B-BIRA, not shown), even though all BIRA retrievals use the same surface reflectivity" is misleading. The retrieval is the same (same surface reflectivity), but the geometry of the 2 instruments is different, as well as the time of the day and clouds", so we expect different scattering weights.

page 8, line 14: a discussion of table 3 wrt to differences in the slant columns values between the different retrieval is missing (discussion on VCD, AMF and background correction has been done before).

page 8, line 18: what is the difference between the temporal correlation reported in figure 7 (and here in the text) and temporal correlation values of table 2 ?.

page 9, line 9: I find the sentence "Aside from OMI-BIRA, the shape factors used in the retrievals are not a significant source of error" a little bit odd. If I understand well table 3, the difference in VCD bias when considering the original profile and when using the CAMS profile is 8% (from -20% to -12% bias) for OMI-BIRA, which is indeed the highest change, but the other products ranges between 7% (for GOME2B-BIRA), to 6% (OMI-SAO), 5% (OMPS-SAO), 3% (GOME2A-BIRA) and finally 1% (OMPS-PCA), which are not so different than 8%. Please reformulate this sentence.

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